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10.18.10/69

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Patentanmeldung Nr. Patent application No. Demande de brevet n°

03100816.2

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For the President of the European Patent Office

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R C van Dijk

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Anmeldung Nr:
Application no.: 03100816.2
Demande no:

Anmeldetag:
Date of filing: 28.03.03
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

LumiLeds Lighting U.S., LLC
370 West Trimble Road
San Jose,
California 95131
ETATS-UNIS D'AMERIQUE

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Multi color LED source design for color-Uniform Application

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s)
revendiquée(s)

Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

F21V8/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of
filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL
PT SE SI SK TR LI

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Multi color LED source design for color-Uniform Application

When light sources of different color are used to create a uniform illumination source a problem of achieving good color uniformity arises. Not only the number of emitters of each individual color must be selected properly but they also must be placed in an optimal pattern in order to avoid disturbing local color variations. The illuminating optical system may have a special color mixing arrangement (e.g. edge-lit LCD backlight with a color mixing light guide) or have poor (direct backlight) or virtually no color mixing arrangement (edge-lit LCD backlight without additional color mixers). Both require separate design rules. The emitters can be light sources of essentially different color (e.g. red, green, blue) or light sources whose color was meant to be the same but came out slightly different due to the fabrication process variations, for example phosphor-converted LEDs with varied thickness of phosphor layer or multi-die RGB white packages with varied brightness of individual dice.

In patent WO02/090826A1 several designs of multicolor LED light sources for backlighting are described. Current Invention Disclosure provides a number of alternative designs. According to the claims of said patent the light source is composed of a number of clusters, each cluster having the same composition – the same configuration of red, green and blue LEDs within the cluster. Furthermore, according to the claims of the patent WO02/090826A1 the placement of the LEDs within the cluster must be symmetrical with respect to an imaginary plain perpendicular to the line along which the individual emitters are placed. Both restrictions pose severe restrictions on the source often leading to sub-optimal light source configuration.

We propose the following new light source designs and rules.

1) A linear light source for a backlight system with a large mixing length, e.g., for an edge-lit backlight with color mixing arrangement. For such a system the LEDs are not assembled in clusters.

a) Achieving color uniformity by selecting placing positions

5 i) Essentially all color must be placed along a line, such that the distances between emitters of the same color, is the same between all LEDs from that color. For each emitter from a specific color that is closest to the edge, the distance to the edge of the color mixing arrangement must be the half of the distance between two emitters of the same color.

10 ii) Application of rule 1)a)i) will give conflicts in placing LEDs in a line, since the number of locations where LEDs can be placed is discrete and limited. Thus, it is desired to have LEDs of different color in the same spot of the linear light source. This dilemma must be dealt with in the following way. First all LEDs of the least numerous color are placed equidistantly. Secondly,
15 the LEDs of the second least color are placed. If the desired spot for placement is already taking by an LED of the least numerous color, a nearby spot must be selected. The rule of equidistant placement must be followed as closely as possible for this second color. Thirdly, (or finally, depending on the number of different colors applied) the LEDs of the third least numerous color
20 are placed, by filling up the open locations.

b) A light source that is constructed according to rule i) and ii), deviates from one that enables optimal color uniformity because of the discrete locations where the LEDs are placed and because deviations of the optimal locations are necessary since two LEDs of different color cannot sit on the same spot. This non-optimality
25 is assuming that all emitters within a color have identical color and brightness.

As a consequence, over the length of the light source, there will be areas where the content of a given color is too high and there will also be areas where the content of that given color is too low. By selecting emitters that are brighter than the average of a given color on spots within an area where it's content is too low, a more uniform light source
30 can be achieved. The same result can also be achieved by selecting dimmer emitters of the complementary colors. Another way to improve color uniformity is to select the color of the LEDs such that a more uniform result is achieved. The three solutions can be combined (and / or) into one approach. This approach assumes that there is enough variation in color and

brightness in LED fabrication and that the color and brightness of the individual emitters is known with certain accuracy.

2) A linear light source for a backlight system with a short mixing length, e.g., for a direct backlight. The emitters are clustered into identical groups but:

- 5 a) The cluster configuration within the cluster is not symmetrical. In particular, as a light source for the direct backlight we propose an linear arrangement of LEDs composed of 4-LED clusters with the following color configuration: GRBG. The light source configuration is thus: GRBGGRBG...GRBG.
- 10 b) To improve the color uniformity we propose to place LEDs with the flux deviating from the average in the area's of the light source where the color point would otherwise deviate from the average. In particular, for the above light source configuration for the direct backlight we propose to use the emitters with the flux at least 1.3x lower than average flux at the underlined positions in the sequence: GRBGGRBG...GRBG. Alternatively, we propose to use the emitters with the flux at
- 15 least 1.3x higher than average flux at the underlined positions in the sequence: GRBGGRBG...GRBG.

The only figure shows five embodiments of light sources according to the present invention. Each of these embodiments comprises a number (11 till 40) of Green (G), Red (R) or Blue (Blue) LEDs.

CLAIMS:

1. A light source providing the illumination of a large area with the light of uniform color composed of a number of individual light emitters arranged in a straight line each emitting the light of a color different from the color of light emitted by some other emitters in said source and distributed over the distance comparable with linear dimensions of the illuminated area. Said light source has the following characteristics:
- it contains several color sets of emitters, each color set emitting light of essentially the same color (and spectrum).
 - the emitters are arranged in such a way that the emitters of the color sets containing the smallest number of emitters are arranged essentially equidistantly over the length of the light source.
2. A light source as described in Claim 1 with the emitters arranged in such a way that the emitters of the two color sets whose XYZ color tristimulus values differ most from each other are placed next to each other along the line or circumference of the source.
3. A light source as described in Claim 1 with the emitters arranged in a periodic fashion, so that the light source is composed of small sub-sequences of emitters, each sub-sequence containing the emitters from all color sets arranged in an identical order. Said sub-sequence does not have to be symmetrical.
4. A light source as described in Claims 1 and 2 with some color sets containing the emitters with luminous light output substantially higher and/or lower than the average light output of emitters in this color set.
5. A light source as described in Claims 1, 2 and 4 with the emitters with luminous light output higher and/or lower than the average light output of their respective color sets located close to the outer ends of the light source.

6. A light source as described in Claims 1-5 with the emitters with luminous light output higher and/or lower than the average light output of their respective color sets located in the area where the distance between the emitters of the color sets deviates from the average distance between the emitters of this color set. If the local distance between the emitters of this color set is less than average, the emitters with lower than average luminous output are used; if the local distance between the emitters of this color set is greater than average, the emitters with higher than average luminous output are used.

ABSTRACT:

The invention relates to a light source providing the illumination of a large area with the light of uniform color. This source comprises a number of individual light emitters arranged in a straight line, each emitter emitting the light of a color different from the color of light emitted by some other emitters in said source and distributed over the distance comparable with linear dimensions of the illuminated area. Said light source has the following characteristics:

- it contains several color sets of emitters, each color set emitting light of essentially the same color (and spectrum).
- the emitters are arranged in such a way that the emitters of the color sets containing the smallest number of emitters are arranged essentially equidistantly over the length of the light source.

Fig 1

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1		G	G	G	G
2		R	B	B	R
3		B	R	R	B
4		G	G	G	G
5		G	G	G	G
6		R	B	G	R
7		G	G	B	G
8		G	G	R	B
9		B	R	G	G
10		R	B	G	R
11		G	G	B	G
12			G	G	G
13			B	R	B
14			G	G	R
15			R	B	G
16			B	G	G
17			G	G	G
18			R	R	B
19			B	B	R
20			G	G	G
21			G	R	R
22			G	G	B
23			R	G	G
24			B	G	G
25			G	R	G
26			B	B	G
27			G	G	R
28			R	R	B
29			G	G	G
30			G	G	R
31			G	B	G
32			B	R	B
33			R	G	G
34			G		R
35					G
36					R
37					G
38					B
39					R
40					G

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